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SPRUCE BUD WORM AND SPRUCE LEAF MINERS.

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BULLETIN No. 210.

SPRUCE BUDWORM.*

(*Tortrix fumiferana* Clemens.)

O. A. JOHANNSEN.

For the past two or three years the spruce budworm has proved the most serious pest of the spruces in Maine. It appears to be a native of this country for it is here that the species was first described in 1865 and there are accounts of the ravages of an insect believed to be this as early as 1807. It is at present widely distributed over eastern Canada, northern England, New York, Vancouver, and Manitoba. The fact that the insect chiefly attacks the buds and new shoots makes its presence in timber lands a serious problem.

HISTORY AND DISTRIBUTION.

The earliest account we have of the appearance of what is believed to be this insect, is given by Professor Packard in the Fifth Report of the U. S. Entomological commission, p. 835, which reads as follows:

"From Rev. Mr. Kellogg we learned the following interesting facts regarding the appearance of the similar, most probably the same species of caterpillar, even upon the same farm that was ravaged in 1878, early in this century. According to Capt. James Sinnett and Mr. John Jordan, of Harpswell, the spruces of Harpswell and Orr's Islands were destroyed in 1807. Captain Bishop, whose son made the statement to Mr. Kellogg, cut down the dead spruces on these islands and worked

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six weeks boiling the sea water with fuel thus obtained, in order to make salt. This was during the embargo which led to the war of 1812 with Great Britain. It is interesting to note that the budworm in 1878 appeared on the same farm on which the spruces had been destroyed by a worm in 1807, or about 80 years previously."

Of course we do not know that the insect referred to in the foregoing account is the spruce budworm, but it is extremely probable. The first authentic knowledge we have of this species came with a publication of the technical description in 1865 by Mr. Brackenridge Clemens of Easton, Pa., who described it from specimens received from Virginia. In 1869 Mr. C. T. Robinson redescribed a brown variety under the name *Tortrix nigridia* believing it to be an undescribed species. The specimens were obtained from Ohio, Pennsylvania and Massachusetts.

It was not until the late seventies and early eighties that the insect again came into prominence because of the great damage it caused to the spruces along the coast of southwestern Maine. Professor A. S. Packard in the Fifth Report of the Entomological Commission (1890) gives us an excellent account of this outbreak and we can do no better than quoting from his work.

"..... From inquiries and field work carried on in June and July 1883, in different parts of Maine, we have little doubt but that the destruction of spruces and firs along the coast of the State was mainly due to the attacks of this insect.

"The different climatic causes alleged to destroy forest trees in general, would, in the present case, have injured pines and hardwood trees as well as spruces and firs, and the destruction would have been general; whereas the trees have been killed by a caterpillar which is not known to live upon pines nor any trees but spruce, fir, and occasionally the hemlock and larch. Individual trees, or clumps of trees, were attacked, whether in high and exposed situations or in hollows; occasionally from such centers the worms seem to have increased and spread from year to year, until all the trees in localities several square miles in extent were killed. Moreover, as we have seen in the case of the attacks of larch worms, the defoliation of spruces and firs repeated two and perhaps three summers is sufficient to either kill the tree outright, or so weaken it that bark-boring beetles can complete the work of destruction. We are now inclined to the opinion, then, that the Bud Tortrix is the sole or at least the main cause of the destruction of spruces and firs in Cumberland, Sagadahoc and Lincoln Counties, Me., and that by their attacks they render the trees liable to invasion by hosts of bark beetles.

"We next visit Harpswell Neck, and found from our own observation and by inquiry from others that a large proportion of the spruces and firs for a distance of about 10 miles have died within about four years. The pleasure of driving over this picturesque road, with its striking northern harsh and wild scenery and frequent glimpses of Casco Bay, in former years greatly enhanced by riding through bits of deep, dark spruce forests, has been not a little marred by the acres and even square miles of dead spruces, stripped of their dark sea-green foliage, reduced to skeletons, and presenting a ghastly, saddening, and depressing sight, which border the road. And, indeed, one may travel through the spruce forests of the coast from Portland to Rockland and meet with similar sights.

"We visited late in August, in company with A. G. Tenney, Esq., the farm of Mr. William Alexander, passing, before reaching the road leading to his house, an area of several acres from which the spruce growth had been cut off in consequence of their widespread destruction by insects. Mr. Alexander informed us that the spruce trees were, in his opinion, killed by small caterpillars which have been at work for five years, but which were most destructive in 1879. These caterpillars he described as being the young of a small brown moth which laid its eggs in autumn; the caterpillars hatching from them were not inch-worms, but when fully grown the body tapered towards both ends, and were about three-quarters of an inch long, and were most destructive June 20, when they are seen among the buds at the ends of the branches, where they draw the leaves together, eating the buds and not the leaves. He had also seen borers in the trees, but he thought the death of the tree should be attributed to the bud-worms rather than to the borers. As will be seen further on, a number of caterpillars were found by us late this summer feeding upon leaves of the spruce and fir, but the worm observed by Mr. Alexander was probably one of the leaf-rolling caterpillars, a species of the family Tortricidae. A number of spruces and firs with their leaves still on but of a bright red, were observed scattered along the roadside; but no signs of leaf-worms or borers were observed in such trees, although the dead, leafless trees were infested with bark-borers.

"I was informed by the late C. J. Noyes, Esq., of Brunswick, who was a summer resident at Merepoint, that in June and the first week in July, 1878, the spruces and firs were attacked by great numbers of 'little measuring worms, like the currant worm in shape', which eat the buds at the ends of the branches; since 1878 they had mostly disappeared, and in the summer of 1881 he had noticed only four or five.

"From Harpswell Neck we traced dead spruces and firs around to West Bath, where extensive forests had been destroyed and numbers of dead hemlocks were observed, while the wood was attacked and the bark undermined and perforated by Buprestid borers, bark borers, and the pine-weevil (*Pissodes strobi*). We have nowhere seen hemlock trees, which are more exempt than any other coniferous trees from the attacks of insects, so much infested.

"The death and destruction of spruce forests were reported to us at Rockland, Me., and at Calais, Me., the destruction having been observed by Mr. Sewell at the latter town in 1879. From these facts there is good reason to suppose that perhaps a third of the spruce and fir forests from near Portland to Calais have been destroyed by insects, most of the work of destruction having been accomplished four or five years ago, during 1878-79.

"Similar damage has been done at points ten or twelve miles from the sea and in the interior of the State. The injury was especially noticed in North Topsham, near the Bowdoinham line. According to the statements of Mr. Willis, the agent of the Feldspar works in North Topsham, forwarded by Dr. C. A. Packard of Bath, Me., the spruces were in 1879 attacked by borers and also by small caterpillars, 'not measuring worms' (probably like those observed by Mr. Alexander at Harpswell.) The trees thus defoliated leaved out, becoming green again; and in 1880 and 1881 the evil seemed to be diminishing, as has been noticed at other places.

"*Further facts regarding the extent of the ravages of the spruce bud-worm in Maine.*—The following facts regarding the extent of the ravages of this caterpillar on the coast of Maine were gathered during the summer of 1883, and for want of space omitted from the report published in that of the Entomologist of the Department of Agriculture.

"The westernmost locality at which the spruce bud-worm was observed was on Peak's and other islands in Portland Harbor, the spruce not extending in any great quantity west of that city. The spruces about Sebago Lake were also destroyed by this worm or a similar caterpillar, in 1878, as we are informed by Rev. Mr. Kellogg, a Mr. Townsend being his authority. Around the shores of Casco Bay and on many of the islands, especially Birch Island, Orr's Island, Jewell's Island, and Great or Harpswell Island, also on Harpswell Neck, Mere Point, Prince's Point, as well as other peninsulas extending into Casco Bay, wherever the spruces and firs grow thickly, extensive areas of these trees were observed; also similar masses of dead spruce were observed along the Maine Central Railroad, from Portland to Brunswick, and thence to Bath; also on the shores of Cathance River, at and near Bowdoinham, Me. Wherever the fiords or narrow bays and reaches extend inland, in Cumberland and Sagadahoc as well as Lincoln Counties, the spruce and fir forests clothing their shores had been invaded by this destructive caterpillar. Wherever the spruces were abundant on the Kennebec River, below Bath, particularly on the eastern side, at and near Parker's Point, and also at and west of Fort Popham, there were extensive patches of dead spruces. Similar but smaller masses of dead spruce were observed along the steamer route from Bath to Boothbay Harbor, at and to the eastward of Southport; none were observed on Mouse or Squirrel Islands. In the course of a journey, at the end of July, from Brunswick along the coast to Eastport, we were

able to ascertain the eastern limits of the ravages of this worm. Several clumps of spruces which had just died were seen on the Knox and Lincoln Railroad before reaching the Wiscasset Station. At Waldoboro, southeast from the station, was an extensive area of dead spruces which presented the same characteristic appearance as in Cumberland County, and for two or three miles beyond Waldoboro there were to be seen large masses of dead spruces and firs. Beyond Warren no dead spruces were to be seen; none were observed about Rockland, Camden, Blue Hill, or the Islands of Penobscot Bay; none on Mount Desert, or on the islands from Mount Desert to East Machias, nor on the road from East Machias to Lubec, although the predominant growth is spruce. No dead spruces were to be seen about Eastport, nor along the railroad from St. Stephen's to Vanceboro and thence to Bangor. From personal observation and inquiry it is safe for us to report that east of the Penobscot River, in eastern Maine, south of Aroostook County, there are no areas of dead spruce. Returning to Brunswick from Bangor, the characteristic patches or large clumps of dead spruce and fir were not seen until we reach a point south of Richmond, and near Bowdoinham, on or near tide-water on the Cathance River. The general absence of any extensive areas of dead spruces around the Rangeley Lakes and the White Mountains has already been referred to in our report. It thus appears that the injury from this worm has been confined, at least south of Aroostook County, to an area on the coast extending from Portland to Warren, and extending but a few miles inland from the sea to tide-water.

"The injury resulting from the attacks of the bud caterpillar are characteristic, as we have stated, the trees dying in masses or clumps of greater or less extent, as if the moths had spread out from different centers before laying their eggs and the caterpillars, hatching, had eaten the buds and leaves, and caused the trees to locally perish. From all we have learned the past season we are now convinced that the spruce bud worm (*Tortrix fumiferana*) is the primary cause of the disease on the coast. As remarked to us by the Rev. Elijah Kellogg, of Harpswell, Me., who has observed the habits of these caterpillars more closely than any one else we have met, where the worms have once devoured the buds the tree is doomed. This, as Mr. Kellogg remarked, is due to the fact that there are in the spruce but a few buds, usually two or three at the end of a twig; if the caterpillar destroy these the tree does not reproduce them until the year following. If any one will examine the buds of the spruce and fir they will see that this must be the case. Hence the case with which the attacks of this caterpillar, when sufficiently abundant, destroy the tree. We have not noticed that the spruce and fir throw out new buds in July and August after such an invasion, the worm disappearing in June. On the other hand, the hackmatack or larch when wholly or partly defoliated by the saw-fly worm (*Nematus*) soon sends out new leaves. By the end of August we have observed such leaves about a quarter of an inch

long. In the following spring a larch which has been stripped of its leaves the summer previous will leave out again freely, although the leaves are always considerably, sometimes one-half shorter. Now, if any one will examine the leaf buds of the larch it will be seen that they are far more numerous than in the spruce and fir or other species of the genus *Abies*, being scattered along the twig at intervals of from a line to half an inch apart. Hence the superior vitality of the larch, at least, as regards its power of overcoming or recuperating from the effects of the loss of its leaves in midsummer. Besides this, the bud worm of the spruce and fir is most active and destructive in June, at the time the tree is putting forth its buds, while the hackmatack, which drops its leaves in the autumn, has become wholly leaved out some weeks before the saw-fly worms appear. For these reasons, while the spruce and fir usually die if most of the leaves and buds are eaten after the season's attack, the larch may usually survive the loss of leaves for two seasons in succession.

"In addition to the facts regarding the great abundance of the bud worm we may cite information given us by Prof. L. A. Lee, of Bowdoin College, who observed the bud-worms in June, 1880, upon the spruces at Prince's Point, Brunswick, and had no doubt but that they were sufficient to cause the death *en masse* of these trees. In 1883 we visited the locality, and many of the trees had been cut down for fuel....."

"During the season of 1886 and 1887, as in 1885 no traces of the caterpillars or moths of *Tortrix fumiferana*, formerly so destructive to the firs and spruce, were discovered."

For a period of 25 years there was no reoccurrence of any serious injury caused by this insect, and it was not until about 5 years ago that we again find them beginning to be troublesome. Dr. Fletcher records them from Manitoba in 1907. In July 1909 myriads of the moths were noticed in western New York, many gaining entrance into houses and barns, where the females unable to find a suitable place for the deposition of eggs laid them upon window sills and casements. Thousands found their death in the arc lights of the streets. In Canada, Dr. Hewitt states that in 1909 the larvae were defoliating considerable areas of balsam and spruce in the upper Gatineau region about 100 miles north of Ottawa. They are carried considerable distance by the wind and this method of disposal accounts for the rapid spread of the insect. During the succeeding years the insect has spread over a wide territory covering southeastern Canada east of Lake Huron, southward to the Gulf of St. Lawrence, eastward to Nova Scotia, all of northern New England and northern New York. In Canada

there are in addition several infestations in more western localities as in Manitoba and Vancouver, while in the United States in Philadelphia in July 1911 the moths were so abundant that according to the daily papers street car traffic was suspended on one occasion owing to the moths upon the tracks. Dr. W. E. Britton (Twelfth Report, 1912) states "In Connecticut I have never seen them as abundant as they were the past season."

According to the observations of Dr. Packard the infestation of 30 years ago in Maine was practically confined to the coast region westward of the Penobscot river chiefly in Knox, Lincoln, Sagadahoc, and Cumberland Counties. The present outbreak covers a much wider range for we have records of the occurrence of the caterpillars from Aroostook, Penobscot, Piscataquis, Hancock, and Waldo counties. In the vicinity of Castine, on the shores of Penobscot Bay and in the Moosehead lake region the insect was first reported in 1911, and though in all probability it occurred in various localities the previous year no reports were received at this Station of its occurrence in 1910, in Maine. The following extract from a letter of July 5, 1911 received from Mr. E. L. Dean of Greenville Junction gives an idea of the situation in that locality.

"We think the worms have all transformed to pupae, and most of the pupae have hatched into moths which are getting to be very numerous in the woods now. As nearly as we can learn the infested region is from the East Outlet of Moosehead Lake to Township No. 4. Range 6, B. K. P. W. K. P. We have not heard of any of the worms north of Moose River. We cannot say how far south they are, but the center of the infestation seems to be in the vicinity of Parlin Road. The worms have been working on all sizes of spruce and fir trees and we think they have worked more on the fir than on the spruce. The worms have eaten this season's growth and the small trees from which the entire season's growth has been stripped are apparently dead."

HABITS AND DESCRIPTION.

The first intimation that we usually have of the presence of the spruce bud worm is in the late spring or early summer when we see the trees by the roadside as well as in the woods look as if a light fire had passed through them. The little caterpillars feed upon the needles of the new bud or terminal

shoots. They gnaw the base of the needles, separating them from the twig, spinning them together by means of the silken thread they secrete. The larva thus forms a loose shelter, moving about in the space between the twig and the loosened needles and bud scale, and not, like many leaf-rolling caterpillars, living in a regular tube. The seriousness of the attack of this insect upon the conifers lies in the fact that the caterpillar feeds upon the buds and new growth, not turning its attention to the older growth until the young needles are entirely consumed. A recurrence of the attack for two or three consecutive years in severe infestations would cause the death of the tree.

The trees which are liable to attack are firs, spruces, larch (or tamarack,)* hemlock and white pine. According to observations made by Mr. Wm. C. Woods in the region about Houlton, the firs are most susceptible. In woods where white, red and black spruce occur, the first mentioned is chiefly affected. At Houlton the larches were also injured. Our own observations made in the vicinity of Orono, Castine, east shore of Penobscot Bay and Seal Harbor on Mt. Desert Island confirm those of Mr. Woods. On estates where the Norway spruce is found it vies with the white spruce in susceptibility to attack. The injury to the trees is most conspicuous about the time the larva is full grown, that is about the middle of June in the vicinity of Orono. At this time the fragments of the leaves left by the worms and the frass are quite conspicuous, and at a distance trees which are seriously affected appear as scorched by fire (Fig. 8). Late in the season after the emergence of the moths, winds and rains have removed loose dry leaves and frass so that the tree, unless the old foliage has also been eaten no longer presents so desolate an appearance.

The caterpillar (larva) begins feeding when growth starts in the spring becoming full fed between the first and middle of June. (Fig. 5). They are then about four-fifths of an inch long, of a reddish brown color, and have small light yellow warts on each segment of the body, the sides of the caterpillar are light in color. Sometimes they have a slightly greenish

*Often though erroneously called the Juniper in Maine.

tinge. About the middle of June they transform to brown chrysalids (Fig. 6) inside the loosely made shelters. In a week or ten days the small grayish brown moth (Fig. 7) emerges from the chrysalid dragging the empty case practically out of the larval shelter. The moths may be seen on the wing from the middle of June until toward the latter part of July. Though the moth is prettily marked with brown and black, the scales which adorn the wings are very easily rubbed off so that the insect when caught frequently appears to be of a uniform yellowish gray. Shortly after emergence the moths deposit their peculiar pale green scale like eggs in small oval patches (Fig. 4) on the sides of the needles, and they are not conspicuous. About Orono the eggs were deposited early in July hatching in a week or ten days. By July 27 nearly all egg masses examined were empty. It is said that the larvae feed on the terminal shoots of the branches for a short time before hibernating, and that they pass the winter as a very small caterpillar in a little shelter constructed near the bud. Extended search in the vicinity of Orono, by several experienced observers, and at Castine, Harborside, and Seal Harbor on Mt. Desert Isl., by the writer failed to reveal a trace of the young larvae. As it is certain that the young larvae do hibernate their disappearance this season in these localities seemed almost inexplicable. The only reasonable explanation which we have to offer is that the little caterpillars immediately after emergence were eaten by small spiders which were very abundant upon the spruces and which were seen to feed upon them on several occasions.

DETAILED DESCRIPTIONS OF EGGS, LARVA, PUPA AND ADULT.

Egg. (Fig. 4) Pale green, scale-like, broad, flat, beneath, moderately convex above, oval cylindrical, finely but irregularly granulated. The shell is thin, and at first very soft. Length 0.9 to 1.4 mm.; breadth 0.8 to 1 mm. The patches about 3 mm. in diameter, and composed of as many as thirty eggs. The eggs overlapped each other irregularly, leaving about a third or fourth of the surface of each egg exposed.

"Larva, first stage. When first hatched the young caterpillar is uniformly pale peagreen, with a yellowish tint. Head dark brown, but the cervical shield pale amber, with two dark dots on the hinder edge; hairs nearly half as long as the body is thick; length 2.5 mm. At this

time the young worms are very active, letting themselves down by a thread as readily as when fully grown.

"Larva before last molt. Body not quite so thick as full-fed worm; more uniformly rust-red brown; the piliferous warts duller in color, sometimes not much paler than the rest of the body towards the head, though higher and more distinct towards the end of the body. Head black and prothoracic shield black, the latter pale on front margin; no well-marked, broad, lateral, yellowish-brown band. Length 12 to 13 mm.

"Larva (full-fed): Body unusually thick and stout, tapering gradually from the middle to the end, and slightly flattened from above, as usual; head not quite so wide as the body, of the usual form, dark, almost black-brown, but lighter than before the last molt, mouthparts dark, with paler membranous rings at the articulations; antennae with the terminal joint black.

"Prothoracic shield pale brown, paler than the body, with a pair of dark blotches on the hinder edge in the middle, and other scattered, smaller, dark, irregular blotches, of which two are situated in the middle of the front edge, the latter pale whitish. Body rich umber-brown, diffused with olive-green, especially on the sutures; with very conspicuous and showy, large, whitish-yellow, piliferous warts, forming flattened minute tubercles, with a dark center from which the hair arises. On the top of the second and third thoracic segments is a transverse row of four warts on each segment; on the upper side of the abdominal segments are four warts arranged in a short trapezoid; they are far apart transversely, but unusually near together antero-posterior to the body; on the penultimate segment is a median, broad, light-yellowish spot on the hinder edge of the segment; a large, round, convex area, forming the supra-anal plate, from which arise about six fine, long pale-brown hairs. Anal legs spreading, with two or three piliferous callosities; the terminal segment and anal legs concolorous, with an irregular, broad, pale-yellowish lateral band reaching to the prothoracic segment, and slightly tinged with ferruginous. In this band, on the side of each segment, is a pale-whitish, flattened wart, directly in front of and adjoining the spiracle; along the narrow, lateral, fleshy ridge on each segment is a long, narrow, pale-yellowish wart. Beneath dull, livid greenish, with (on each segment) a transverse row of four bright-yellowish warts, concolorous with those above; the two inner ones are minute, the outer ones much larger. Thoracic legs black-brown; the four pairs of abdominal median legs are pale, almost whitish; all the hairs are fine and light-brown in color, and one-half as long as the body is broad. Length 19 mm.

"Pupa. Body very thick, the thorax especially unusually swollen; the body, soon after changing, pale horn-colored, striped with brown; antennae and legs dark horn-color or dull tan-brown; wings pale, with the veins dark; the thorax pale horn, spotted with dark tan-brown, with three irregular, dark, dorsal stripes; meso-scutellum and metanotum

dark; abdominal segments above, with two rows of stout spines; a lateral row of dark spots, and a medium spot on the two basal segments; similar spots on the succeeding segments lengthened and connecting the lateral spots. Beneath are two irregular rows of diffuse spots; the hinder edge of the segments darkened: the terminal segment uniform dark, shining, tan-brown, ending in a long, stout point, on each side of which are two tightly-curved spines, and two stouter but less curled larger ones at the end, arising from a common base. Length 12 mm.

Moth. A large species, with a stout body and large broadishlong fore wings; the costa not excavated towards the apex, but full and regularly though slightly curved, the apex being rectangular, head and body umber-brown. Palpi very stout; terminal joint short; fore wings umber-brown, the brown sometimes replaced by rust-red; ground-color bluish-slate; on the inner fourth of the costal edge are four unequal, triangular, brown spots, the second and fourth connecting with an elongated transverse brown patch in the middle of the wing. From a point at or just within the middle of the costa a very oblique, distinct, broad, brown band crosses the wing in a zigzag course, ending at or near the outer third of the internal edge of the wing. This broad band extends out towards or connects with a preapical brown patch on the costa; it also sends an angle inwards behind the median vein, and again another angle outward opposite the inwardly-directed angle. There are often two distinct, costal, whitish dots (sometimes wanting) just before the apex, while the apex itself is brown. There is also a large brown patch in the middle of the wings near the outer edge. There are numerous fine, short, transverse, brown lines dividing the wing into squares or checks, bordered with brown. The bands and short lines are more or less confluent or separate, varying much in this respect. Some females differ in the umber-brown, being bright rust-red, and the clay-blue pale ferruginous brown, while the broad, median, zigzag band is umber-brown on the edges and bright rust-red in the middle, and the wing is covered with an irregular net-work made by the short transverse and longitudinal dark-brown lines inclosing rust-red or smoky-red patches.

"Legs, body, and hind wings glistening umber-brown; tarsi ringed with pale brown. The abdomen of the female is very stout, that of the male ending in a long, distinct, hairy tuft. Described from perfectly fresh specimens, five males, eight females. Length of body, 9 to 10 mm.; of fore wing, 10 to 12 mm.; expanse of wings 19 to 22 mm."

NATURAL CONTROL.

BIRDS.

A correspondent in Ellsworth sent us specimens of the pupae of the spruce bud moth stating that she had observed the purple martin to feed upon them. This very useful bird, once common enough in Maine is now found locally distributed and apparently decreasing in numbers.

SPIDERS.

The part that spiders are evidently taking in holding the spruce budworm in check has already been briefly indicated. Our first observations on this point were made in the laboratory. To study the habits of the young caterpillars of the spruce bud moth we had taken a small balsam fir tree about a foot high, transplanted it into a flower pot and placed upon it, a dozen or more needles collected in the open which had upon them freshly laid eggs of the moth. In due time the eggs hatched but in spite of frequent examination very few small larvae were seen, and these soon disappeared. As the tree was small and kept under close observation in the laboratory the absence of the young larvae puzzled us until we chanced to see a little spider holding in its chelicerae a young larva and sucking it dry. Continued observation showed that the two spiders which were present on the little tree were quite capable of exterminating the several hundred newly hatched little larvae which emerged from the dozen or more egg masses with which the tree had been stocked. Unfortunately these little spiders were lost so that we cannot now say to what species they belonged, excepting, that they looked like members of the family Theridiidae. A few days after these observations were made specimens of small spiders were collected from spruce trees on which egg masses of the spruce budmoth were abundant. These were submitted to Mr. J. H. Emerton so well known for his work upon the spiders of New England, who determined them for us. In the lot were specimens of *Theridion spirale*, *T. difференс*, *Linyphia phrygiana*, *Dictyna volupis*, and an immature *Tetragnatha*. On the campus spruces, though egg masses had been easily located, the only young caterpillars seen were a few

on July 29 and these were pounced upon by small spiders and devoured, while we stood by, in a manner highly suggesting an explanation of the scarcity of newly hatched caterpillars which was certainly a peculiar sequel to the abundance of the season's moths.

PARASITIC INSECTS.

The parasitic insects which we have found belong to the two orders *Hymenoptera* and *Diptera*. Of the former several different species have been reared by us, of the latter, the only species we have reared is the following.

DIPTERA.

Exorista vulgaris Fallen.

Kongl. Svenska Vetensk. Ak. Handl. XXXI. 1810. Osten Sacken. Canad. Ent. XIX. p. 163 1887. (*hirsuta*)

Male. Eyes thickly pubescent, front about one and one fourth times as wide as either eye, frontal vitta velvety dark brown with a reddish tinge, about half as wide as the front; vibrissae inserted in level with the oral margin; sides of front silvery as well as the sides of the face, cheeks and the facial depression, cheeks hairy; antennae descending below the level of the lower margin of the eye, the third joint about four times as long as the second, arista thickened to the middle; palpi and proboscis black; frontal bristles descending to below the base of the third antennal joint; orbital bristles wanting. Thorax black, shining, with four more or less distinct pollinose stripes; scutellum black, its apical margin with a paler tinge; pleura pollinose; four post sutural bristles; sterno pleurals three. Abdomen shining black, segments largely white pollinose, second, third and fourth segments bearing discal as well as marginal bristles. Legs black, middle tibiae each with a single bristle on the front side near the middle; hind tibiae outwardly irregularly ciliate with longer and shorter bristles; pulvilli white. Wings hyaline, grayish tinged, apical crossvein slightly incurved at the base; posterior crossvein slightly though distinctly sigmoid curved; halteres brown; calypteres white. Length 7 mm. Bred from pupae brought by Mr. Wm. C. Woods from Houlton. Lot No. 1513.

In the course of a study of the parasites of the spruce budworm in Canada by the Division of Entomology a new species of Tachnid fly was reared in considerable numbers. A descrip-

tion of this species named *Winthemia fumiferanae* is given in the Canadian Entomologist. Vol. 44 pp. 2-3.

HYMENOPTERA.

Pimpla Ontario.

Cresson. Trans. Amer. Ent. Society. Vol. III p. 146.

"*Pimpla Ontario*, Male. Black, shining; face, clypeus, mandibles except tips, palpi, spot on scape beneath, tegulae and apex of scutellum and post-scutellum, white; wings hyaline, iridescent, stigma and veins.



Fig. 1. *Pimpla inquisitor*: a. full grown summer larva; b. hibernating larva; c. mouth parts of larva; d. adult female; e. abdomen of adult male from sides,— all enlarged. (After Howard. Technical Series No. 5, 1897.)

blackish, the former with a white spot at base, areolet small, 5-angular; legs yellowish-red, four anterior coxae and trochanters beneath white, posterior tibiae and tarsi blackish, with a broad annulus on the former and basal half of first joint of the latter, white; metathorax shining, delicately punctured, with a short pale pubescence, apex rounded; abdomen long, narrow, sub-cylindrical, closely and delicately punctured; antennae long, subrobust and of uniform thickness throughout. Length 5 lines.

Hab. Canada."

This species was bred from specimens sent to us from Greenville Junction in 1911 as well as from material brought by Mr. Wm. C. Woods from Houlton, July, 1912. Lot 1544. It so closely resembles *Pimpla inquisitor* that Fig. 1 will give a good idea of this beneficial insect.

Pimpla conquisitor Say.

Say, American Entomology Vol. II. 1869 p. 689. (*Cryptus*.)

"*C. Conquisitor*. Black; tergum with the posterior margins of the segments white; feet honey-yellow; posterior tibiae and tarsi with black joints.

"Inhabits Indiana.

"Body black, punctured; palpi white; thorax, punctures minute: a longitudinal white line before the wings; metathorax not distinctly punctured on the disk: wings very slightly tinged with dusky; nervures blackish; stigma rather large, with its base and tip whitish; second cubital cellule oblique: tergum densely punctured on every part; segments on their posterior narrow margins, white: oviduct about half the length of the abdomen: feet honey-yellow; intermediate and posterior tarsi white, the joints black at their tips; posterior tibiae black, white in the middle.

"Length one-fourth of an inch.

"Resembles *inquisitor* nob., but the posterior margins of the segments of the tergum are white."

This species was bred from the budworm by Professor Fernald years ago.

Apanteles sp. (*Braconidae*) has been reared by us from the spruce budworms which were collected near Orono. Lots 1486, 1509, 1510.

Dr. C. Gordon Hewitt, Dominion Entomologist records rearing a number of species from the budworm in Canada. These have recently been described by H. L. Viereck, in Vol. 42, Proceedings of the United States National Museum. The species are *Apanteles fumiferanae*, *Meteorus trachynotus*, *Conoblasta fumiferanae*, *Phygadeuon (Dirophanes) plesius*, *Epiurus innotatus* and *Mesochorus diversicolor*, of which the first four are from province Quebec, the last two from British Columbia. *Nasonia tortricis* Brues is another Canadian species parasitic on the spruce budworm.

A number of egg masses collected in Orono, late in the summer showed evidence of having been affected by egg parasites, but unfortunately none was reared.

REMEDIAL MEASURES.

In timber lands it would be quite impracticable to adopt measures for the control and eradication of the spruce bud-worm other than in aiding in the spread of the beneficial para-

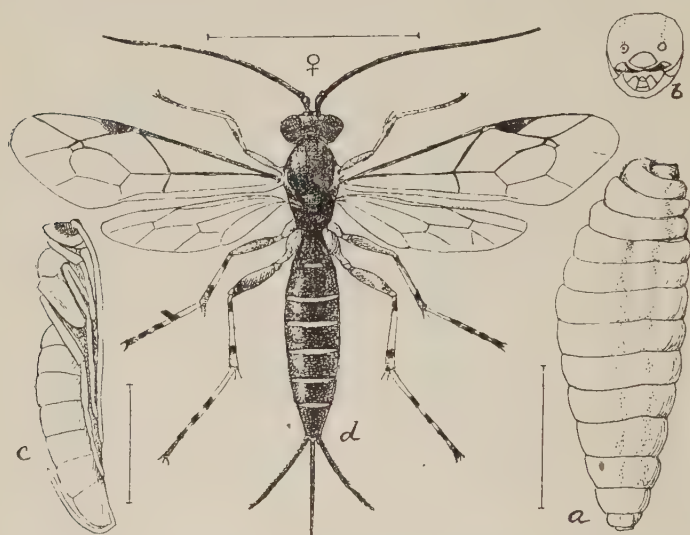


Fig. 2. *Pimpla conquisitor*. a. larva; b. head of same; c. pupa; d. adult female,—all enlarged. (After Howard. Technical Series, No. 5, 1897.)

sites. In limited areas, however, as in the case of the protection of ornamental trees of an estate or the young trees in a plantation it would be quite easy to use an arsenical spray which would keep the pest under control. This is rendered all the easier by the fact that we are here dealing with a native insect, which is subject to attack by native parasites and which, if we may judge by its history in the past, will succumb to its natural enemies within a very few years. If we can restrain its activities for a season or two it appears probable that we may not be troubled by it again for decades.

SPRAYING.

As far as we know, little or no effort has been made to check the injury caused by the spruce budworm by spraying, although we see no reason why the insect may not be controlled by the method employed in combating similar species upon other trees. The time when the greatest amount of injury is being done is in the late spring, about the first of June in the vicinity of Orono. To prevent injury to the spruces therefore it will be advisable to begin spraying operations soon after the young shoots open and repeat within a week or ten days. Arsenate of lead applied at the rate of five or six pounds per 100 gallons of water is doubtless the simplest and most reliable remedy.

The question is often asked, what will it cost to spray and what will be the expense involved in the purchase of a suitable equipment? As there are no figures available in regard to spraying for the spruce budworm we must turn to other sources for information. Those given by Professor Herrick in the *Journal of Economic Entomology* (Vol. 5 page 169) upon spraying for the elm leaf-beetle are recent and as the methods used in combating this insect are similar to those which must be employed against the spruce budworm we will quote directly from Professor Herrick's paper. The part that concerns us reads as follows:

"The first question that presented itself of course, was the matter of apparatus. Our appropriation was not large and it, therefore, became necessary to limit ourselves to reasonably inexpensive and tried outfits. After much correspondence and several interviews with agents, we decided to purchase a Hardie Power Sprayer with a triplex pump, 3 H. P. engine, 200-gallon tank, 12-foot tower, two leads of hose, each 100 feet long and two extension poles, one 20 feet long and the other 12 feet in length, and a Friend Hilly-Orchard outfit with a 3 1-2 H. P. engine, California model pump, 8 foot tower and other equipment like the former outfit. With these outfits, and both gave eminent satisfaction, we were able at all times to maintain 175 to 200 pounds (and over) pressure. One man remained on the tower and with his 20-foot extension pole and Bordeaux Nozzle was able to reach the tops of the very highest trees. The man on the ground ran the engine, drove the team, and sprayed the lower branches. The so-called foreman directed the work, mixed the solutions, attended to breakdowns, climbed trees if necessary, and kept things going in general.

"The first spraying was made from May 16 to May 25, and the second from June 12 to June 22.

"We used 3 lbs. of paste arsenate of lead the first time over the trees and 3 1-2 lbs. to 50 gallons of water the second time.

"A careful and detailed record of the actual cost of spraying 435 trees was kept. Most of these trees were large and all of them stood near the street and near our water supply. It cost \$133.37 to spray these trees once or 30.7c per tree. On the average each machine sprayed 36 1-4 trees per day of eight hours, or 4 1-2 trees per hour or a tree about every 13 1-3 minutes. On an average we used approximately 18 1-6 gallons of liquid to each tree.

"A detailed example of a day's work on the largest trees will give even a better idea of the cost of spraying such trees. On June 19th the two machines began on the largest elms on the Campus, namely those from the Library south along each side of Central Avenue. The two machines sprayed 59 of these very large trees. The cost of the men and teams were \$17.00, the arsenate of lead \$6.61 1-2, the gasoline 35c, total \$23.96 1-2, which is an average of 40.6c per tree.

"In all, there are about 530 trees on the University Grounds that were sprayed. About 100 of these were scattered over the steep hillsides west of the buildings and along University and Stewart Avenues. Many of these trees were a mile from our water supply and the majority were scattered and not easy to reach. It cost, exclusive of permanent equipment, \$464.90 to spray these trees twice or an average of approximately 88c. each. The scattered trees just mentioned raised the average cost of the whole, quite materially. If all of the trees had stood along streets and reasonably near a water supply the average cost would have fallen I think, below 70c. It took the two machines ten days to make the first spraying and eleven days to make the second. The second spraying was done more thoroughly and there was much more leaf surface to cover. On the other hand, experience had made the men more efficient."

As will be seen the outfits mentioned in the above account are quite similar to those usually used in the spraying of apple orchards which may be purchased, complete with tanks, hose, rods, etc.; for from 300 to 400 dollars each. In localities where orchard spraying is practiced it would therefore be a very simple matter to hire an equipment with experienced men to run it.

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TWO SPRUCE LEAF MINERS.

Recurvaria piceaella Kearfott.

Journal N. Y. Ent. Soc. XI. 155. 1903.

Packard Fifth Rept. Ent. Com. 850, 1890 (*Gelechia obliquistrigella* Pack., nec Chambers).

The life history of this species has been described by Mr. W. D. Kearfott in the Journal of the N. Y. Entomological Society. As our own observations confirm those of Mr. Kearfott we will quote his account adding only the new locality reference and dates.

"*The eggs* are laid within a reasonable time after the moth's emergence, in due course the young larvae hatch and begin a very minute mine, which is slowly enlarged until cold weather causes torpidity, and until the earliest sunny and warm spring days, when they desert the old mines and begin new ones (in previous season's leaves) usually farther out or nearer the end of the twig."

"*Larva* The head is pale brown, prothoracic shield same but lighter. Skin red on dorsal, lateral and ventral regions, a dark green patch on each abdominal segment, on central dorsal area. On ventral surface of thoracic segments, between each pair of legs is a deep purplish red spot; on segments 5 and 6 there is one such spot on each segment on center line." Length 6 to 7 mm.

"*Pupa*.—Body rather thick, of the usual pale mahogany brown color, the antennae and tips of the wings on the under side reaching to the middle of the fifth abdominal segment. End of the abdomen full and rounded, with about ten unequal, irregularly situated slender bristles, which are slightly curved at the end; besides these there are several fine bristles along the side of the body near the tip. Length 5 mm." (Packard Forest Insects. p. 850).

"*Moth*. Fig. 3. "Head cream-white; antennae with the basal (second) joint white, beyond ringed with white and black. Palpi white, first and second speckled with black, second (longest) joint ochreous at the end; third (last) joint with two black rings of unequal size, the outer the longer; the tip white. Fore wings moderately wide, oblong ovate. Ground color ochreous whitish gray, costal region blackish, base black. A broad oblique band proceeds from the costal edge to the middle of the submedian space, ending in two white spots; there are some whitish scales on the outer edge of the band. Just before the middle of the wing is a broad irregular black band, and beyond it in the submedian space a black spot. A third broad black band crosses the wing, ending on the hind margin and breaking up into three black spots on the hind margin; the band incloses near them two twinned white dots. Near the

outer fourth of the wing is a conspicuous white line, sharply bent outwards just behind the middle of the wing; beyond the apex of the angle of the line are several white scales. At the base of the fringe is an oblique line of black scales. The fringe, like the adjoining part of the wing, is of mixed gray ochreous, with black scales. Hind wings rather broad, pointed, pearly slate gray. Legs, including tarsi, banded with black. Expanse of wings, 13 mm. When rubbed the green color of the fore wings becomes paler, and the three oblique black bands are more distinct." (Packard 1890 p. 851.)

"Marking same as *R. thujaella*, except the light shades have an ochreous tone rather than fuscous as in *R. thujaella*. The average size of *R. piceaella* is about one mm. greater than *thujaella*. Otherwise, the two species are very difficult to separate in the imago state. Alar expanse 9.5 to 11.5 mm." (Kearfott 1903.)

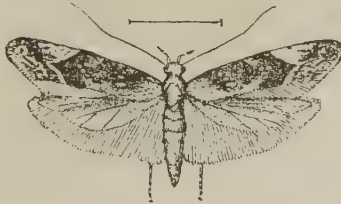


Fig. 3. *Recurvaria piceaella* enlarged. (From Packard 1890 p. 850.)

Professor Packard recorded this species on both red spruce and fir from Peak's Island, Casco Bay, Maine, the moth being on the wing at and soon after the middle of July. Larvae were collected by us from Norway spruce on the Campus of the University of Maine, Orono, Maine, about the middle of May, 1912, associated with the larvae of *Epinotia piceafoliانا*, from which they differed by being a little smaller and with body reddish with brown head and shield. The moths emerged late in June. Lot 1493.

Epinotia piceafoliana Kearfott.

Journal N. Y. Entomological Society. XVI. 176, 1908.

About the middle of May 1912, some of the Norway spruces upon the Campus of the University of Maine, at Orono, were found to be affected by the larvae of a small moth. Many of the leaves of the last season's growth were found to be dry and yellow in appearance and more or less appressed to the twig (Fig. 9). A closer examination showed that each of the affected needles was hollowed out and tenanted by a little greenish larva which had gained entrance through a circular hole near the base of the leaf. The mature larva is about 6 mm. long, stout and greenish or yellowish green in color. The head, prothoracic shield and the legs of the thorax are black. When grown they spin a dense white cocoon. This cocoon lies between the needles close to the twig. The moths emerged late in June, though no observations were made upon this, it is probable that the eggs are laid soon after and that the young larvae hibernate within the leaf mines, resuming activity in early spring completing the life cycle, in the same manner as *Recurvaria piccaella*. Mr. Kearfott who first described this species states that the larvae feeds upon the needles of black spruce (*Picea mariana*) at Montclair, N. Y., the moths appearing early in June. The moths have also been taken in Cincinnati, Ohio, the middle of May. Those reared by us in Orono emerged in June.

Moth. "Expanse 9.5 to 10.5 mm.

"Head light gray, tinged with yellowish on top; palpi short, scarcely extending beyond head, tuft small, flattened, the scales at outer end not concealing the short, obtuse outer joint, color gray, shaded with blackish on outside, apical point dusky black; antennae gray; thorax light cinerous gray, with a bronzy median shade; abdomen bronzy black, anal tuft gray-ocherous; legs gray, heavily dusted in front and tarsi ringed with bronzy black.

"Forewing.—Costa nearly straight, slightly curved at base and apex, termen straight and only slightly oblique. Twelve veins, all free, accessory cell large, beginning midway between 10 and 11, outer end opposite 7; internal vein ending opposite 5. Color grayish white, crossed with blackish lines and narrow fasciae. The basal area is defined by a heavier dark dentate line, from inner fourth of costa, curving outwardly to inner third of dorsum; before this are three or four parallel fine dark

lines on a gray-white ground, each starting with a blackish costal dot. From middle of costa to before tornus is a narrow dark fascia, interrupted by a white oblique line on middle of cell, below which an obtuse spur of the dark color on the outer edge of fascia. Between this fascia and basal area is a broad fascia of ground color traversed by broken dark lines, and on costa forming two white spots, each usually divided by a blackish dot. Beyond the dark fascia, the apical third is whitish gray, crossed by parallel dark line, starting as black costal dots and separated by four white costal spots. The apex is black and defined below by a white dash through the black terminal line and extending to outer edge of cilia. Ocellus not defined. Cilia dark leaden-gray.

"Hindwing.—Smoky back, cilia dark gray, with a darker basal line. Eight veins, 3 and 4 stalked. Underside both wings dark smoky gray, costal spots repeated on forewing, and the latter grayish white below fold." (Kearfott 1908.)

PARASITES.

We have reared from this insect three different species of hymenopterous parasites, *Porizon sens lat* (June 7 to 12), Lot No. 1483; *Climocentrus* sp, Lot 1511; and *Microdus* sp., Lot 1512.

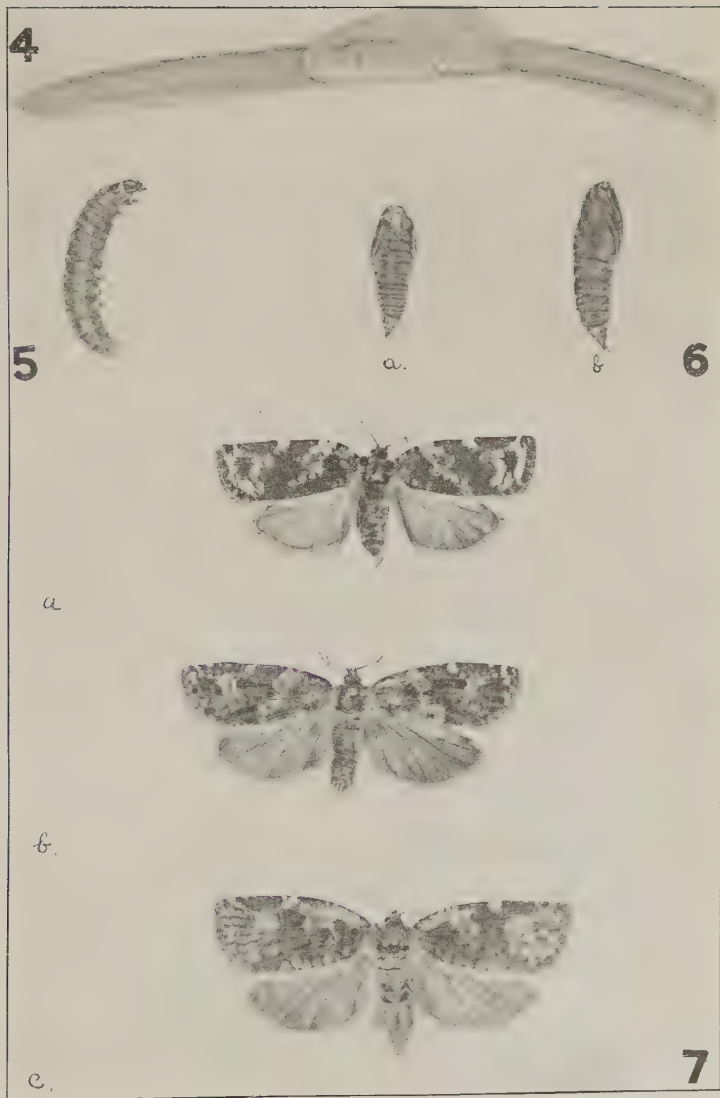
Rhogas Canadensis Cresson.

A specimen of this species was taken at Orono, May 15, 1912, on a Norway spruce twig upon which there were many larvae of *Epinotia piccafoliana*, and it may therefore possibly be a parasite upon it. Mr. Cresson's description of the species reads as follows:

"Female. Black fuscous, opaque; face, mouth, palpi and orbits, dull rufo-testaceous; antennae fuscous; middle lobe of mesothorax, scutellum, most of pleura, spot on each extreme side of metathorax (sometimes wanting), legs, except tibiae and tarsi, and the abdomen beneath, rufo-testaceous; tibiae and tarsi, semi-circular spot at tip of first abdominal segment, and the second and third segments except sides, luteous; apical segment pale fuscous; wings ample, hyaline, iridescent, nervures fuscous; stigma whitish varied with fuscous; metathorax and abdomen finely sculptured. Length 6 mm." Cresson. Trans Amer. Ent. Soc. II. 380. 1869. (*Aleiodes*).

The species was originally recorded from Canada.

This Maine specimen differs from the above description in having a dusky face, yellowish scape, and yellow basal joints of the tarsi. Professor J. C. Bradley compared this specimen with the type at Philadelphia verifying my determination. Lot 1463.



Spruce Budworm. Fig. 4. Egg mass on spruce leaf. Orono, July 16, 1912. Fig. 5. Larva. Fig. 6 *a*, male pupa; *b*, female pupa. Fig. 7. Moth, showing three of many variations in markings;—*a* and *b* were dark gray, and *c* bright brown.



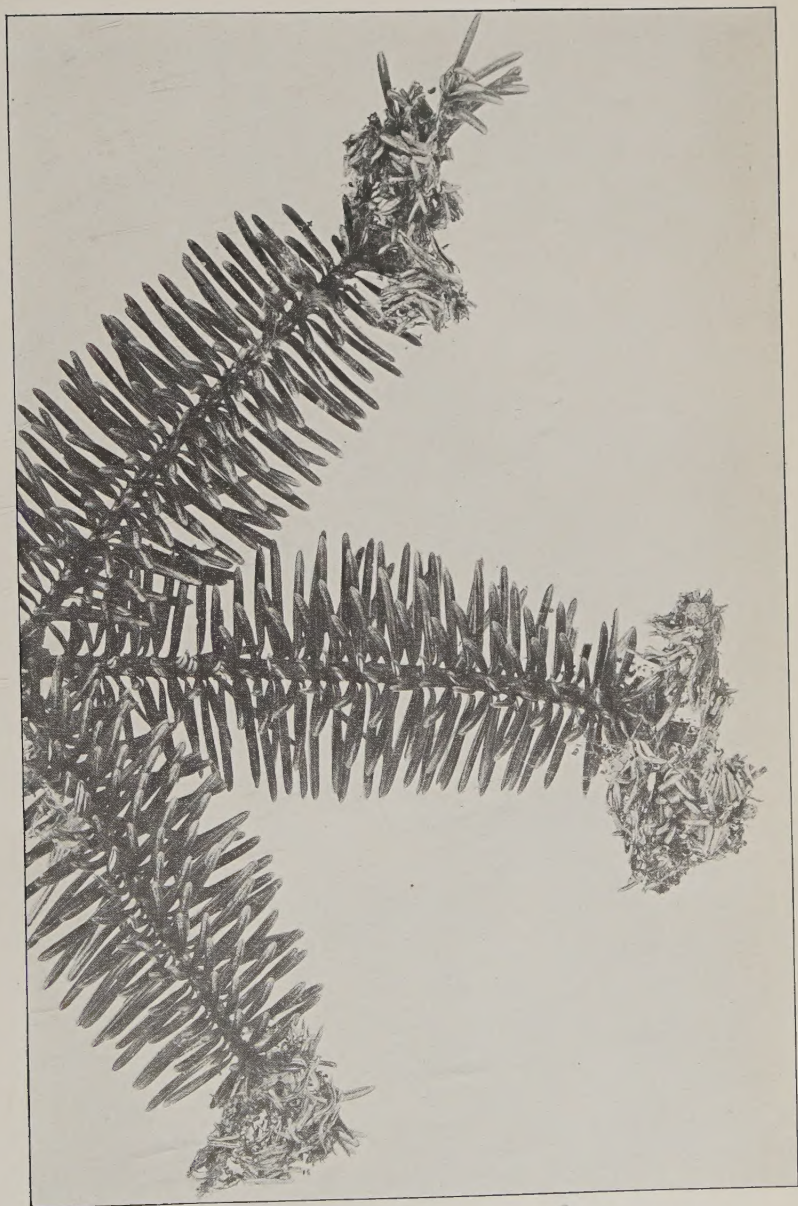


Fig. 8. Work of Budworm on Balsam Fir. Orono, June 11, 1912.

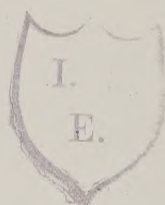




Fig. 9. Work of Leaf-miner on Norway Spruce. Notice area of depressed leaves.

